

# J0316+4328: A New Gravitational Lens

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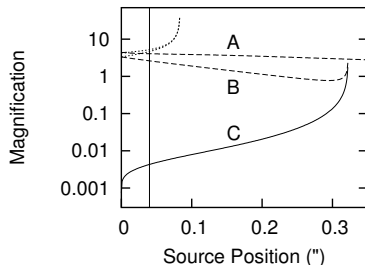
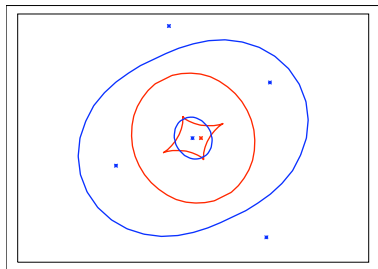
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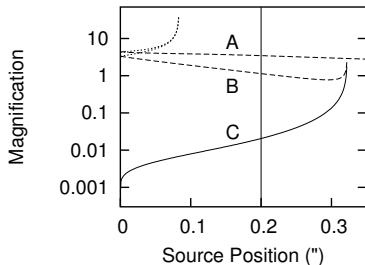
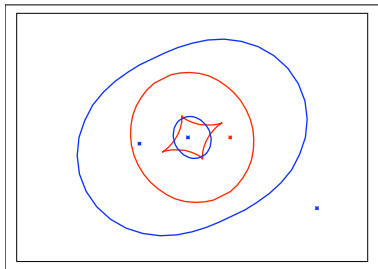
Searching for Strong Lenses  
in Large Imaging Surveys  
Fermilab, 15/06/2007

# Symmetric Lenses



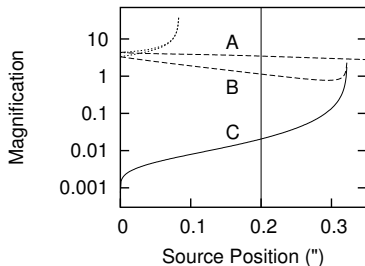
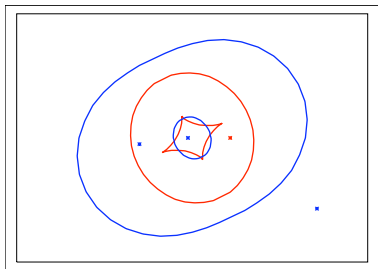
- Red: source and caustics  
Blue: images and critical curves
- When the source and galaxy are closely aligned, 4 bright images or 2 bright images at similar magnification

# Asymmetric Lenses



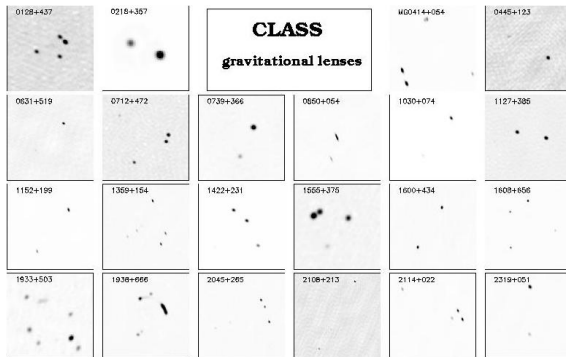
- When the source is further from the galaxy, get brighter central image, 2 bright images with very different magnification

# Why are Asymmetric Lenses Interesting?



- Central image is brighter (less demagnified)
- Images A, B form at very different radii:  
probe density profile over larger scale
- Image B forms closer to lens galaxy center:  
absorption measures gas, dust in lens galaxy

# The CLASS Survey



- 22 systems: compact radio sources, galaxy lenses (separations  $0''.3$ - $2''.0$ )
- First cut: 8.4 GHz VLA
- Followed up with 5 GHz MERLIN, VLBA

# CLASS Catalog

- 11,685 radio sources, selected from GB6 (5 GHz) and NVSS (1.4 GHz) catalogs
- $S_5 > 30$  mJy,  $\alpha > -0.5$  between 1.4 and 5 GHz
- 8.4 GHz VLA snapshots (30s on source), rms  $\sim 0.2$  mJy, resolution  $0''.2$ - $0''.3$
- Cut-off of 10:1 on flux density ratio for two component systems (to ensure completeness for  $S_8 > 20$  mJy)

# Following Up CLASS

## Asymmetric Candidates

- Start with CLASS automapped sources, extract 243 sources with two components at flux density ratio 10-30
- Remap by hand, to check the automapper
- Many examined, followed up at Jodrell Bank:  
Tom York & Stuart Lowe (MSc. project),  
Neal Jackson & Satoru Sakai  
(small separation lenses)

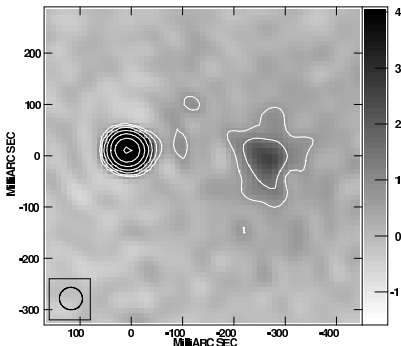
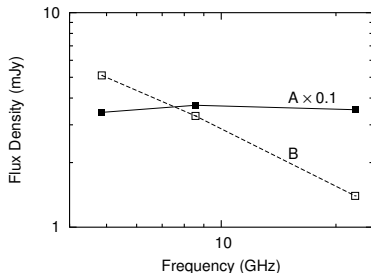
# Higher Resolution with VLA, MERLIN

- VLA: 18 candidates observed at 5, 8 GHz, 8 of those observed at 22 GHz
- MERLIN: 2 candidates observed at 6 GHz
- Most sources ruled out:  
extended secondary and/or different spectra
- J0316+4328: probably a lens



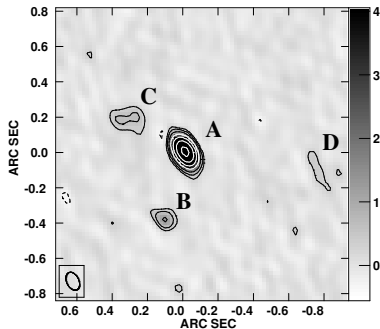
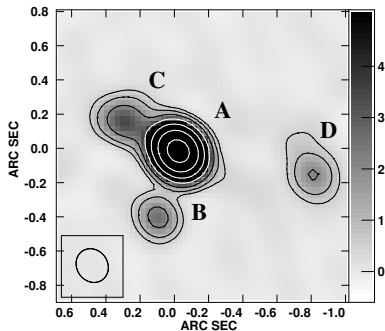
# Rejected Candidates:

## J2139+1027 and J0856+4935



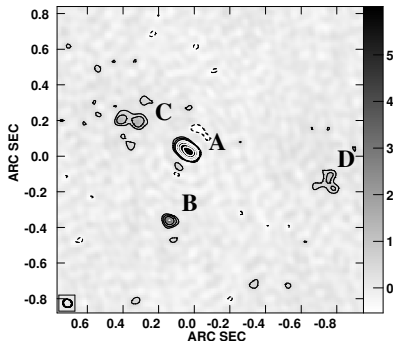
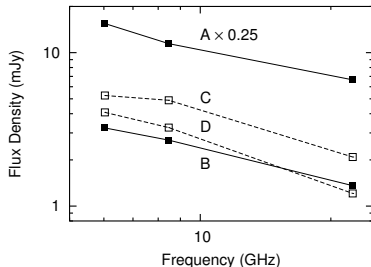
- (l) J2139+1027 VLA spectrum
- (r) J0856+4935 MERLIN map

# J0316+4328: VLA



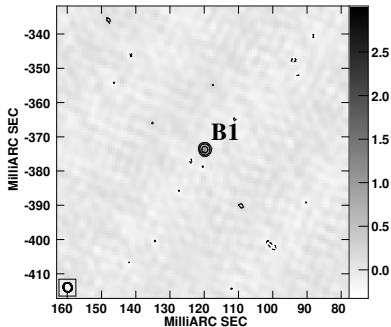
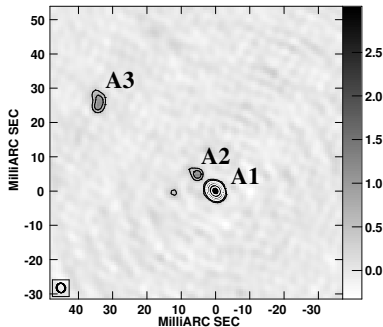
- (l) 8 GHz, beam  $0''.20 \times 0''.18$   
(r) 22 GHz, beam  $0''.11 \times 0''.07$
- 2 compact, flat spectrum components (A, B)
- 2 extended, steep spectrum components (C, D)

# J0316+4328: MERLIN



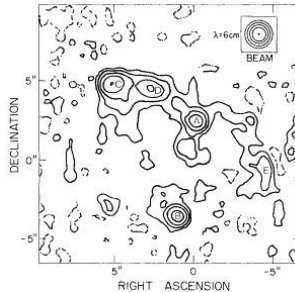
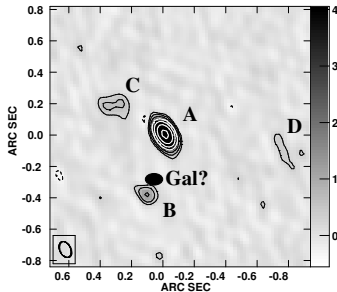
- (r) 6 GHz MERLIN, beam  $0''.051 \times 0''.045$
- A, B still compact, same ratio
- C, D resolved, steeper spectrum
- (l) Spectra of components

# J0316+4328: VLBA



- 8 GHz VLBA, beam  $2.8 \times 2.5$  mas, (l) A, (r) B
- A, B detected with same flux density ratio
- Substructure only in component A
- C, D completely resolved out

# J0316+4328: Lensing Configuration



- Source has compact core & extended lobes
- 2 images of core, flux density ratio 19:1 (largest), separation 0".40 (2nd smallest)
- 1 image of each lobe, like B0957+561 (r)

# J0316+4328: Final Confirmation

- 22 of 23 CLASS targets with compact VLBA components were lenses (exception: components had different spectra)
- Applied for High Sensitivity Array, will look for matching radio substructure, maybe a central image?
- Final confirmation needs optical follow-up, applied for WHT imaging, Lick spectroscopy